View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Research Papers in Economics

Individual learning and team functioning

Marco Novarese

Centre for Cognitive Economics; Università del Piemonte Orientale
e-mail: marco@novarese.org; web: www.novarese.org

Preliminary version
July 2004

Comments are welcome

Abstract: This paper aims at studying the effects of learning - seen as a possible source of individual heterogeneity - on team functioning, in an experimental game requiring cooperation and coordination. It contributes to the new emergent cognitive approach to Economics. The empirical analysis starts from some general hypothesis but has mainly a descriptive purpose. Results allow confirming previous findings: individuals tend to developed high-routinized paths of behaviour, extending the strategies learned in the past, to the new situations faced. Learning processes, yet, are not based on the mechanical repetition of the same choices (participants to this experiment proved, for example, in fact, to be able to imitate and replicate the strategies of their previous partners). A significant heterogeneity in the behaviour, related to personal traits and to the training treatment emerged. The second part of the game allows to understand how significantly such individual differences affect team performance in the same task. Best teams require a mix of similarity and heterogeneity among members.

Keywords: heterogeneity, learning, experimental economics, cognitive economics

Jel: C90, D83, B5

Introduction

Learning is one of the aspects at the centre of the attention in the contemporary literature. Different models and definitions have been proposed and experimentally tested. This paper contributes at this stream of analysis, starting from the cognitive economic approach. This is a new area of research, posed at the crossroads of the heterodox Economics tradition and Cognitive Sciences. It is focused on the study of individual and organizational learning, seen as a key factor in shaping social phenomena and defined according to a psychological view that differs from the traditional Economics' one. In fact it is not seen as a *walk towards optimality* but as the *human capacity to modify behaviour in a more or less permanent way, whenever new experience is acquired* (Novarese and Rizzello, 2002). Individuals knowledge is based on models of the worlds, that are applied beyond the situations in which they have been developed and where proved to be successfull.
This process does not lead all individuals to develop the same perception of the environment, both because the external conditions in which they live can be different, and because their personal traits are not homogeneous (in the tendency to be repetitive, in the attitude toward their partners, in the levels of expectation …). So, the same conditions cause various reactions and therefore stimulate the development of different kinds of routines.
It is then important to study how individual differences influences social and organizational situations. The managerial literature, for example, has shown how strongly some personal characteristics of the workers can affect firm performance. Economics has generally given less attention to the role of the single in the social functioning. There are yet some remarkably exceptions, which demonstrate how this discipline can contribute and get useful results from this idea.

This paper aims at studying the effects of learning, as a possible source of individual heterogeneity, on team functioning, in an experimental game requiring cooperation and coordination.
In a previous work (Novarese, 2004), I tested the effect of the training in different social contests on the individual behaviour, in the same kind of game under exam here. The present analysis aims at confirming such findings and to widen the understanding of the effect of team composition on its performance

The first paragraph proposes a brief presentation of the wide literature relevant for the present analysis. After some remarks on the learning literature, the attention is focused on the studies whose aim is that of entering the black box, linking individual and organizational behaviour. The experiment is then described. The third paragraph proposes the results. Conclusion follows.

2. Theoretical background: inside the black box, individual and organization

According to the neoclassical view, the organization is a *black box*, in which inputs are transformed into the output in a way that is not known and is also not worth to be studied.
The theory of the firm born with the aim of explaining the "nature" of this agent (Coase, 1937) but not with the interest of understanding its real functioning (see Foss, 1999).

In the last years a new approach to economic analysis has developed and has began to be called *cognitive economics.* Egidi-Rizzello (2003) and Rizzello (1999) analyse and define in detail such stream of research, its novelty and its link with some important works in the history of Economics ideas.
One of the main area in which this perspective proved to be useful, is just the analysis of organizations. Two different traditions, that present many points of contact (Rizzello, 1999 and Novarese, 2002), should be recalled here:

- the behavioural school (see for example Simon 1991 and 1993, Cyert and March 1963);
- and the recent proposal from evolutionary scholars like Witt (1998), Knudsen-Foss (1999), Langlois (1994) who developed a cognitive reading of the Austrian tradition applied to the firm and to the entrepreneur.

Both these approaches link individual learning and firm functioning, in a heterodox perspective.

They refuse the traditional economic hypothesis on individual behaviour and try to understand and model the real human behaviour. Given this aim, it's necessary to recognize that individual learning and decision making are characterized by a series of bounds, which make generally impossible to reach optimal choices (Rizzello, 1999). Maximization is also hampered by the lack of all necessary information.

The idea of optimization is substituted by that of *satisfaction*. According to this alternative vision, an individual is likely to take a decision *if it allows reaching a given level of satisfaction.* Later, the person will repeat the same action *if it has proved to be successful* in the past, and to change it if it has not. In this way, when a problem is solved in a satisficing way, behaviour tends to become routinized. Routinization is, in fact, an inborn characteristic of human being, useful to reduce mental effort (Novarese and Rizzello, 2004; Egidi 2002).

Human learning cannot, yet, be reduced to a simple repetition of successfull actions, as persons have also the attitudes to reason on what happened, to imitate others, to compare their situation with that of their neighbours, but also the capacity of reflecting on the possible choices of the partners involved in strategic situations … (see Novarese, 2004, for a more detailed presentation of these learning mechanisms).

Also the action of collective actors (like organizations) is based on different kinds of routinized behaviour (Cohen et al, 1996). Such social patterns of repetitive behaviour are rooted in the individual tendency seen before: when subjects internalize a rule that proved to be satisficing, they will use it also in the future and also in other contexts, even if, there, it's no (more) adequate.

Individuals can therefore represent an important bound to organizational innovation, as they can be unable to perceive the new reality and/or not willing/able to change their strategies. Bonini and Egidi (1999), for example, demonstrated that, in an experimental task requiring coordination, organizational lock-in depends on individual path dependence. Many persons continue to repeat the strategies learned in the first part of the game, even in the second one, when new choices would be more efficient.

When different individuals are trained in the same environment, they will generally develop similar strategies. The tendency to imitate the others reinforce such result.

Not all individuals share, yet, the same tendency to behave in a routinized manner. Some of them dislike repetition and are prone to innovate. Literature (for example Schumpeter, 1943) has often defined this kind of people has leaders (and entrepreneurs).

When individuals do not share experiences, besides, their knowledge and their perception of the world will, yet, be very different. Hayek (1945) stressed the relevance of these aspects at a market level, and Rizzello (1999) linked it with his model of learning, and its coherence with the contemporary cognitive approach.

Besides, individual can react in different way to similar situations, because of different attitudes and skills. When facing opportunistic behaviours, for example, players can decide to make a rational choice (accepting to gain less than the other) or try to punish the partner, even at the cost o a loss (see Novarese, 2004). The wide experimental literature on the prisoner's dilemma or on the public goods is another example. Some agents free ride, other cooperate.

Organizational psychologists call "strong situations" the cases in which there are "widely accepted rules of conduct which constrain and direct behaviour" (Weiss and Adler, 1984, p 20; Davis et al, 1989). In contrast, "weak situations allows various interpretations and response to identical issues" (Carpenter and Gold, 1997, p 189), in relation to the personality of the individuals involved. In such cases individual personality matters.

Some management scholars analysed this fact with the aims of understanding the relation between the strategies performed by a team and many individual characteristics of its member (see for example Boone and Van Olffen, 1998 and 2003). Significant results emerged.
The analysis is generally conducted using data gathered trough surveys or experiments. They allow, for example, evaluating the role of some of the managers psychological traits, like the *locus of control* (i.e. the tendency to feel that *persons are the master of their own fates*).

Also some economics works attribute a strong relevance on individual differences, but probably with less emphasis and more indirectly. As seen, Hayek (1945), for example, explicitly takes into account the role and the relevance of individual (tacit and idiosyncratic) knowledge and motivations on the functioning of market and society. Schumpeter (1943) analyses the effect of leadership (an individual characteristic of some persons) on innovation (also at a political level). Witt (1998) directly links the capacity of the entrepreneur of being a leader to the functioning of the firm.
The traditional distinction in the personal propensity to the risk represents another example of the need to consider heterogeneity in explaining economic functioning.
In their pioneering experimental studies on bargaining, the same Siegel and Fouraker (1960) stated the need to take into account the individual psychological traits, as output is not "determined from economic consideration alone, being subject to a host of psychological, historical, and cultural forces as well" (p. 75).

The experiment proposed here aims at studying the effect of individual learning (seen as an important determinant of differences among persons) on team functioning, so linking all the approach recalled.

3. The experiment "Sum 10"

3.1 Presentation

Team of three players are anonymously and randomly built among participants. The game has thirteen rounds.
Each of the players has a set of numbers that remains unchanged in every round and is composed by the values from zero to ten (both included).
In every round each player has to declare one of the numbers in the set.
The numbers of the three people playing together are then summed.

According to the sum, each player receives a payoff, following this rule:

* if S(i) = 10, I(i)=40 - D(i)
* if S(i) > 10, I(i)=30 - D(i)
* if S(i) < 10, individual payoff=0 - D(i)

where
S(i)= sum of the team I, of which player i is a member
I(i)= player i: individual payoff
D(i): number declared by player i

Results are immediately communicated to the players and a new round starts.

The game is divided into two parts. In the first (rounds 1-9) players are coupled with artificial agents. In the second one (four additional repetitions), teams are composed only by the human participants.
The players do not know that they are playing with artificial agents. They are told that in the first

part they will be coupled with two players, and in the second one to two new ones. They do not know the number of rounds.

In two treatments there are different kinds of artificial agents.

1) Treatment one
- One agent always plays "3";
- One agent always plays "3" (first choice) and repeats this number if in the preceding round the human player chooses "4"; if in the previous round the sum was less than seven, it declare "0"; otherwise it chooses the number necessary to get ten according to the sum in the previous round.
Thus, in order to obtain always ten, the human player should choose a number equal or major than "4".

2) Treatment two
- One agent always plays "4";
- One agent plays "3" (first choice) and repeats this number if in the preceding turn the human player chooses "3", otherwise it chooses the necessary number to reach ten (e.g. if the player chooses 2, this agent chooses 10-(2+4)=4; if the player chooses "4", this agent chooses "3").

In the second part, ten teams were built, composed in two different ways:
- teams A: two individuals from the first group and one from the second,
- teams B: one individual from the first and two from the second.

The experiment was organized in the following way. Players have to declare their number using a pre-printed sheet. A team of people managing the experiment collected all the piece of paper. The data were then inserted in a spreadsheet programmed to perform all necessary operations. The results (sum of the team, number played by the others and score) were then written on the sheets and get to the players.
During the session, communication among participants was not allowed and they were carefully monitored so to avoid any interaction.
The experiment last about one hour and a half.
It was carried out in January 2003 at the University of Torino and was organized by the *Centre for Cognitive Economics*. Thirty students in Communication participated. On the basis of the score obtained they were granted credits for one of the two part of their exam (they could raise their grade of three points on thirty, according to a rate of conversion that were not specified to stimulate each individuals to get the higher pay-off as possible).

This experiment is similar but not identical to the one proposed in Novarese (2004)[1]. It's then not possible to compare directly the behaviour of the participants to the two sessions and their reaction to the artificial agents. On the contrary it is interesting to look for eventual similarities in the learning processes.

"Sum 10" represents a metaphor of various strategical situations characterized by the following conditions:

1 Here the interaction among individuals were not mediated by a computer. The students participating in the experiments were attending a course in Communication Science and not in Law. The number of rounds is very low here. Also the artificial agents were not completely identical. In fact, in the previous experiment, because of the numbers available, the human player interacting with the first kind of agent, in order to reach a sum equal to ten, could chose only "4" (here they can declare any numbers higher than "4"). The second agent acted here as an adaptor to the behaviour of the human, trying to impose the choice "3", but accepting other solutions. It's then different from the agent in treatment two of the previous experiment, in which it declared only "4" or "10".

- there are many possible outcomes, more or less efficient for the group as a whole (for example a given good, produced by a group, can be of *first quality* or of *second choice*);
- to reach any of the possible outcomes, it is necessary a certain level of coordination;
- the division of the labour is not centrally planned;
- individuals can contribute in different ways and it is necessary that someone provide a higher level of effort than the others.

Situations of this kind are widespread in the real world at social and organizational level. In fact team performance emerges from the choices of more individuals whose behaviour is interrelated. Both coordination and co-operation are involved and there are many possible outcomes.

These situations are, nevertheless, usually neglected by the economic analysis (both at a theoretically and empirical level) because of their complexity. Economic theory takes into account mainly simple games. Experimental economics uses, generally, the same approach, also because of the need of building environment that can be easily analysed and under the researcher's control.

Cognitive economics proposes a different approach, because of its aim to understand how agents behave in real situations. So empirical analysis has also (and at this stage, mainly) descriptive purposes. This paper contributes to such literature (see Novarese, 2003 and Novarese and Rizzello 2004b).

The game proposed here is, obviously, a stylized situation. It is yet more complex than the usual experimental games. After having understood its basic features and how to analyse them, it will be possible to develop different and more realistic versions.

3.2 Some hypothesis

On the basis of the recalled literature and of previous findings of the same experiments (Novarese, 2003 and 2004), a series of general hypothesis can now be proposed.

1) Individual behaviour in experimental decision-making tasks is heterogeneous.

The higher variability should be found when individual face opportunistic partners. In such cases, some of them choose the rational behaviour. Others do not and behave according to a different model (coherent with other experimental findings) that leads to punish their partners.

Also other kinds of difference should be found.

2) The training, influences how people play the final part. Dissimilar trainings, therefore, lead to different behaviours.

As in the first part players in the same treatments could behave in different ways, their conduct in the second period won't, yet, be identical. So the strategies of the second part should be linked to the performance and choices of the training, given the treatment.

3) As many individual manifest a tendency to modify their behaviour according to the situations experienced, in the second part of the game, the composition of the team matters for its performance, as players can tend to repeat behaviour that were satisficing in the old conditions but that are not necessarily efficient in the new ones.

4. Results

4.1 The first part

Table 1 proposes the mean values of a series of variables in the first part of the game, so to compare the behaviour of the players in the two treatments. Two statistical tests were carried out to prove eventual differences among them: the analysis of the variance and the Kruskal Wallis test for the Wilcoxon *Rank Sums* non-parametric analysis; they lead to similar conclusions in almost all cases.

The main results are the following:
- treatment one has a lower mean score, but the difference is not significant;
- treatment two has a higher percentage of rounds in which the sum is major then ten, probably because of problems of coordination. Even if one of the artificial agents behaves as an adapter (to the previous round), participants have more difficulties in understanding how it plays;
- the mean number of rounds in which participants declared "3" is higher for the second group, but only three persons on fifteen chose it at least four times on height. The mean number of round in which "4" is declared is higher for group one, but the difference is not significant;
- the mean differences between player's score and the score of the other members of the same team (variable DISP1) is lower for treatment one (a positive value means that the individual have got a score higher than the others, a value of zero means that the score is equal among the three partners, a negative value means that participants got a lower score). It's interesting to observe that for both groups, the mean value of such variable is negative. This is partly expected for the first, as artificial agents don't allow different solutions (if players want to reach a sum equal to ten). It's not obvious for the second, in which artificial agents would allow persons to get positive values of DISP1. Most of them fail to understand this fact or are not opportunist.

As the artificial agents in treatment two can act as the ones in treatment one (if players do no behave as strong opportunist), it is not surprising that some of their mean values are similar.

Table 1. Mean value of the main indicators of behaviour in the first part of the experiment by treatments

	tr. 1	tr. 2	p value t test	p-value Kruskal-Wallis Test
mean of total score	175	203	0.43	0.53
mean of satisfaction	5.9	6.1	0.89	1
mean of rounds in which sum =10	3.9	3.3	0.57	0.83
mean of rounds in which sum > 10	**1.3**	**2.6**	0.01	0.01
mean of rounds in which sum < 10	0.9	1.1	0.65	0.65
mean number of 0 declared	0.5	0.5	0.86	0.28
mean number of 1 declared	0.2	0.3	0.68	0.69
mean number of 2 declared	0.3	0.6	0.33	0.38
mean number of 3 declared	**0.8**	**2.2**	0.05	0.08
mean number of 4 declared	4.7	2.9	0.13	0.13
mean number of 5 declared	0.9	1.5	0.23	0.35
mean number of 6 declared	0.5	0.7	0.42	0.63
mean number of 7 declared	0.4	0.3	0.66	0.78
mean number of 8 declared	0.4	0.07	0.24	0.29
mean number of 9 declared	0.07	0.0	0.32	0.35
mean number of 10 declared	0.2	0	0.32	0.35
mean variable DISP1	**-1.8**	**-0.6**	0.007	0.01

A bold type indicates that the value is significant at a level of the 10%

Table 2 shows that between the groups there are, yet, significant differences in the standard deviation of some important variables. Treatment one has a higher variance of the score (and also of the number of rounds in which the sum is equal to ten; while the F-test indicate a low significance in this difference, Levene's test and other parametric tests - like O'Brien, Bartlett and Brown and Forsythe's ones - and the Siegel-Tukey non parametric test state its significance) and of many other indicators.
The variable RMAX is the ratio between MAX2 and MAX1 divided respectively for the number of rounds in the second and in the first part (i.e. four and nine).
The variable MAX measures the attitude to maintain a stable choice (the number at its end indicates if the index is computed on the first or second part). See Novarese (2004) for a discussion of the different indexes that allow to measure such tendency. MAX is computed as the frequency of the most declared numbers in the given part (so, for example, if in the training, a

player choose one time "0", two times "2", fifteen times "3", four times "4" and "10", MAX1 will be equal to fifteen).
RMAX is, so, a way to measure the attitude to maintain fixed choices in both the parts. If a player has MAX1 and MAX2 high (or low) in both the sections, it takes a value of about one. A high (low) value means that in the second part there is a stable (variable) series of choices, while in the first one there was variability (stability).
The mean values of this variable are similar between the treatments, but the first one has more variability among the parts. In other words: players in treatment two maintain the same behaviour with a higher probability; so, players with an attitude to have a high (low) MAX1, will have also a high (low) MAX2.
These results are partly expected, even if treatment two allows a wider set of equilibria (more or less favourable to the players) and then a possible wider dispersion. These wider sets of possible equilibria make, yet, more difficult for the players to understand the game. Results are therefore more levelled near the mean. On the contrary, in the first group, there are seven players who get a sum equal to ten just in one or in no round. All the others get at least four times this goal. This different performance, given the same conditions, is probably again due to the individual attitude to accept or not an unfair solution.

Table 2. Standard deviation of a series of indicators of the first part of the experiment by treatment

	tr. 1	tr. 2	p-value F test	Pr>F Levene's test
score in the first part	**13.210**	**4.158**	**0.02**	**0.01**
number of rounds in which sum =10	**3.4**	**2.3**	**0.24**	**0.01**
number of rounds in which sum > 10	1.5	1.2	0.31	0.37
number of rounds in which sum < 10	**2.5**	**1.2**	**0.08**	**0.01**
RMAX	**1.1**	**0.4**	**0.03**	**0.10**

A bold type indicates that the value is significant at a level of the 10%

4.2 The second part of the experiment

As in Novarese (2004), two aspects will now be analysed: the numbers declared in the second part, in relation to those of the first one, and the tendency to maintain stable choices.
These analyses are more difficult here, as the number of rounds is lower and there are more possible choices (for example, in the first part, in treatment two, only three players declared at least four times, i.e. half of the rounds, the number "3").

Table 3 proposes an easy picture of the relation among the numbers most declared in both parts by the individuals in the two groups (the same results could be shown using regressions but this table seems to be more intuitive). Column 1, for group 1, shows the number declared by the seven players of the first treatment who made the same choice at least five times (more than half of the rounds) and (in parenthesis) its frequency. So, for example, the first players declared the number "4" nine times. Column 3 lists the nine participants of the second treatment in the same situation.

Columns 2 and 4 show the number most declared by each of the same players in the second part (and, in parenthesis, its frequency). MAX1 is the frequency in parenthesis in columns 1 and 2 and MAX2 that in columns 3 and 4. The mean value of MAX2 in columns 1 and 2 are respectively 3.2 and 2.6.
The part labelled "group 2" proposes the same data for the other players. The mean value of MAX2 in column 1 and 2 are respectively 2.6 and 1.8.

Between the first and second part, for group 1, two kinds of links can be found, in relation to the number declared and to MAX2. In some cases the number declared many times in the fist part is also the most proposed in the second (player 2, 16, 17, 23) . In many situations, yet, players evidently imitate the artificial agents they trained with, playing "3", after having chosen a lot of times "4". As seen, the mean values of MAX2 are high than those of the second group, where the links between the two parts are weaker or absent.

Table 3 Numbers most played in the first and second part for each participant to the game

	treatment 1			treatment 2		
	player	column 1	column 2	player	column 3	column 4
group 1	1	4 (9)	3 (4)	16	4 (9)	4 (4)
	2	4 (9)	3 (3)	17	3 (9)	3 (4)
	3	4 (9)	4 (4)	18	4 (8)	3 (4)
	4	4 (8)	3 (3)	19	5 (7)	4/6 (2)
	5	4 (8)	2 (3)	20	4 (7)	2 (4)
	6	4 (7)	3 (4)	21	3 (6)	2 (3)
	7	4 (7)	3 (4)	22	4 (6)	3 (4)
				23	0 (5)	0 (4)
				24	3 (5)	7 (3)
group 2	8	8 (4)	2/5/6/7 (1)	25	6 (4)	5 (2)
	9	4/7 (4)	3 (3)	26	4 (3)	1 (3)
	10	10 (3)	4 (3)	27	5 (3)	3 (2)
	11	4/5 (3)	4 (4)	28	3 (3)	5 (2)
	12	4 (3)	4 (2)	29	-	-
	13	5 (3)	5/7 (2)	30	-	-
	14	6 (2)	4 (2)			
	15	2/3 (2)	0 (4)			

Tables 4 and 5 shows a series of estimations performed to explain the value of MAX2, in relation to two variables expressing the behaviour and the performance of the individuals in the first part: the number of sum equal to ten (SUM10_1) and MAX1.

The observations of the individuals joined in the same teams are not independent. To overcome the problem two different procedures are used.

1) The first (table 4) is the introduction in the model of a variable that account for the correlation in the value of MAX2 among the team: the number of sums equal to ten in the second part (NUM10_2). If a team gets a sum equal to ten for a given period, for that set of rounds, all of its members will have the same value of MAX2. In the estimation, this relation will be kept by the control variable, so eliminating the problem. Similarly, if a group is not able to coordinate, and players change always their choice, MAX2 will be low, as their number of sum equal to ten. The control variable will again account for this mutual relation (see Novarese, 2004 for a longer analysis of this procedure to eliminate the dependence among observations).

Table 4. Estimation with MAX2 as dependent variable, all observations, by treatment

variable	tr1	tr 2	tr1	tr 2
number of sum=10 in the second part	0.48 (0.00)	013 (0.47)	0.48 (0.03)	0.14 (0.47)
number of sum=10 in the first part	0.10 (0.04)	0.36 (0.00)	-	-
MAX1	-	-	0.10 (0.12)	0.33 (0.04
P value F test	0.00	0.00	0.05	0.03
R^2	0.65	0.67	0.59	0.63

"-" indicates a variable not included in the estimation; the value in parenthesis under the parameter estimates is the p-value of the t-test, the number of observation for all estimations is 15

2) As the number of observations is relatively high, it's possible (table 5) to perform regressions on sub samples composed by independent individuals (i.e. players that are in different teams in the second part). These sub-samples allow also testing the eventual effect of the training (one of the sub samples contains five observations from both groups, the others two only individuals from one

of them; the same comparison can be realized with a different composition of the three sets; it lead to the same results).

Estimations are performed for the two treatments separately, so to find eventual differences. In Novarese (2004), in fact, the training in dissimilar environments had significant effects. Here, yet, in the first part there is more homogeneity between the treatments, so few differences should emerge also in the second, as, in fact, shown by tables 4 and 5.

As seen in table 3, players trained in the second group who reached a sum equal to ten many times in the first part, in the second one have rigid strategies and repeat more times the same number. In fact, MAX2 is strongly affected by the performance in the first part. A similar tendency can also be found for the other treatment, but it is weaker: MAX2 is more influenced by the interaction with the partners.
This result, so, confirms the findings of Novarese (2004) on the effects of the training in different contests and on the individual tendency to maintain successful behaviour learned in the past.
The strong effect for the second group could be just a statistical effect. The link between MAX2 and NUM101 can be hide by NUM102. In other words, a player could be repetitive but the effect does not emerge because of the team effect. Therefore the result under analysis would be a reflection of an eventual major efficiency of the teams where the persons from group one play (or of the team where most of them play), but in such case, it would be necessary to explain the superiority of such groups! Again, a learning effect seems, so, to emerge. Next paragraph analyses this aspect.

Table 5. Estimation with MAX2 as dependent variable, by groups of independent observations

variable	tr 1	tr 2	tr 1-2		tr 1	tr 2	tr 1-2		tr 1	tr 2	tr 1-2
number of sum=10 in the second part	0.45 (0.06)	0.30 (0.21)	0.67 (0.03)		0.43 (0.05)	0.15 (0.41)	0.51 (0.08)		0.44 (0.06)	0.20 (0.35)	0.43 (0.14)
number of sum=10 in the first part					0.12 (0.11)	0.25 (0.03)	0.18 (0.13)				
MAX1									0.11 (0.23)	0.23 (0.08)	0.22 (0.12)
P value F test					0.04	0.05	0.03		0.09	0.09	0.03
R^2	0.59	0.19	0.46		0.59	0.58	0.62		0.50	0.50	0.63

"-" indicates a variable not included in the estimation; the value in parenthesis under the parameter estimates is the p-value of the t-test, the number of observation for all estimations is 10

Team behaviour and individual learning

Two kinds of groups played the second part, teams A composed by two individuals from treatment one and one from the other, and teams B made with one individuals from treatment one and two from the second.

Table 6. Mean value of many indicators in the second part of the experiment by team type

	team A	team B	p value t test	p-value Kruskal-Wallis Test
mean of total score	82	104	0.29	0.46
mean of rounds in which sum =10	1.2	2.2	0.22	0.18
mean of rounds in which sum >10	1	1.6	0.45	0.52
mean of rounds in which sum < 10	1.2	0.8	0.47	0.51
sum=10 in the last round	0.2	1	0.00	0.01
mean MAX2	2.6	3.2	0.17	0.08

Table 6 shows a series of indicators of performance for the two kinds of teams.

Two significant aspects emerge. At the end of the game, all teams of type A get a sum equal to ten, while only one of team B reach this goal (two other teams in this set have reached a sum equal to ten, but have not been able to maintain it; all equilibria get by the team A are confirmed till the end). It's not possible to say what should have happened in eventual following rounds. This result seems yet to suggest that teams A could be more flexible and players more prone to adapt to each others.
The difference in the mean value of MAX2 between teams A and B confirms this hypothesis.
Such effect is related to the compositions of the teams, as individual from treatments two proved to be more rigid in their choices and therefore less able to adapt to the others.

Table 7 proposes a series of regressions that use the number of sums equal to ten of each team in the second part as the dependent variable. In this way they explain team performance using as regressors a series of means and standard deviations, reckoned on the individual values of the members of each group.
The idea is that team performance depends on the individual learning, because of the reinforcement effect on the numbers declared and of the tendency to maintain or not a given choice[2].
A team can get a sum equal to ten in many ways. For example, if two individuals maintain a stable choice and the other adapt to them, it will be easier to reach a sum equal to ten. If all of them try to adapt to the previous choices of the partners and change continuously their number, it will be more difficult to find equilibria as in the case in which all maintain the same numbers (not summing to ten).
When equilibrium has been reached, players should maintain the same choices.
These notes show some links between individual behaviour, in term of stability of the choices, and team performance.
A good team will probably have a mix of stable and adaptive players. In term of the previous analysis, therefore, efficient teams will be composed by two (or one) individuals who realized a good performance in the first part (and so developed a stable strategy) and another (or two others) less rigid. So this hypothetical good team would probably have a high standard deviation in the indicators of individual performance in the first part.

Table 7. Estimation on team performance in the second part as dependent variable

	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9
mean value of the dummy on the number of sum=10 in the first part*	3.2 (0.05)	-	2.7 (0.02)	-	4.3 (0.01)	5.3 (0.04)	-	3.4 (0.02)	
mean value of number of sum=10 in the first part	-	-	-	0.67 (0.07)	-	-	0.39 (0.27)	-	
standard deviation RMAX	-	-	-	-	4.3 (0.02)	-	-	2.3 (0.21)	
standard deviation of the dummy on the number of sum=10 in the first part	-	-	-	-	-	-3.3 (0.25)	-	-	
standard deviation of the number of sum=10 in the first part	-	-	-	-	-	-	1.1 (0.15)	-	1.5 (0.03)
mean value DISP1	-	-	-	-	-	-	-	-	
standard deviation of the score in the first part	-	0.03 (0.02)	0.03 (0.01)	-	-	-	-	0.01 (0.10)	
standard deviation RMAX									
P value F test	0.05	0.02	0.01	0.07	0.01	0.08	0.06	0.01	0.03
R^2	0.41	0.51	0.78	0.38	0.73	0.52	0.55	0.83	0.45

"-" indicates a variable not included in the estimation; the value in parenthesis under the parameter estimates is the p-value of the t-test, mean values and standard deviations are computed among members of given teams; the dummy on the number of ten assumes value 1 if the number of ten is at least equal to half of the number of rounds (4) in the first part; all estimations used 10 observations

2 The relation between the number declared in the first part and team performance and equilibria cannot be studied here because of the relatively few observations and of the individual heterogeneity.

Table 7 proposes different specifications of the model. Some of them are based on similar variables. For example the effect of the performance in the first part is analysed using the *mean of the numbers of ten* or the *mean of a dummy on the same numbers of ten*.
The reason for using this last value is easy to understand. If *the number of ten* got by the individuals in the first part is relevant (trough the effect on MAX2), its mean value is, yet, not a good indicator.
Consider, in fact, a group in which one of the player make *eight times* "ten" in the first part, another one *three times* and the last just *one time*. Probably only the first person will show the *reinforcement effect* described and the following high value of MAX2. Imagine another group where all players got four times a *sum equal to ten*. These two teams have the same *mean number of individual ten in the first part* (equal to four), but only in the second case there would, probably, be a reinforcement effect on all the members of the team.
The standard deviation of this dummy variable is, on the contrary, not much informative, as it can assume just few values and, besides, it is also strictly correlated with the mean value (and with few observations that affect strongly the variance of the estimates). Other indicators of variability are then preferable.

As hypothesized, both the mean performance in the first section and its variance among members affects significantly team performance.
Both the variables measuring the mean of the individual performance in the first part are significant (sp1 and sp4). As expected, the dummy on the number of ten[3] increases the fit of the model more than the mean on the number of ten.
Also the variance of the performance in the first part is significant, taken alone (sp2 and sp10).
Inserting in the model both the variables leads to a higher fit (sp1 and 2 vs. sp3 and sp4 and sp10 vs. sp7).

The relevance for the team of the variance in the individual behaviours is confirmed by the specification including the variable RMAX (sp5 and sp811) which demonstrate that teams in which all players tend to maintain the same strategies of the first part are less efficient (the standard deviation of RMAX, in fact, indicates both the differences in strategies in the first part and the tendency to maintain it in the second part)[4].
The significance of the standard deviation of RMAX helps to understand why team of type B - composed by more players coming from treatment one, where the variance of the variable under exam is higher - are more flexible.

Conclusion

This paper proposes an experimental study on the team effects of individual learning, starting from some general hypothesis but without a theory to test. It aims at contributing to the new emergent Cognitive Economics approach, that, in accordance with Simon (1992) and Cyert and March (1963) puts strong emphasis on the need to understand how real agents behave. So descriptive studies are needed to define realistic hypothesis on how individuals build knowledge and develop routines.
The game "Sum 10" proposes a situation requiring coordination and co-operation and allows different kinds of solutions. In respects to the usual experimental game it is so much more complicated and allows less control but represents a step towards the study of more realistic situations.
Despite the shortness of the number of rounds, and the wideness of the possible strategies, some clear results emerged, confirming and extending the findings of a previous sessions of the same experiment (performed with some important difference and described in Novarese-Rizzello 2004

3 It's important to note that in this sample the mean of the dummy take tree values: 0, 0.33, 0.67. There are therefore no team entirely composed by individuals with a strong probability of reinforcement.
4 The standard deviation of RMAX is related to the standard deviation of the score, but it's not the same thing, as a comparison between sp5 and sp8 indicates.

and in Novarese 2004) and of other experimental studies (for example, see: Novarese and Rizzello, 2002, Egidi, 2002 and Egidi and Narduzzo, 1997).
Individuals tend to developed high-routinized paths of behaviour, extending the strategies learned in the past, to the new situations faced. Learning processes, yet, are not based on the mechanical repetition of the same choices. Participants to this experiment, for example, proved to be able to imitate and replicate the strategies of their previous partners. Learning is, in fact, not a simple repetition of the same moves, but implies the construction of a model of the world that inspire the choices.
As in the same (training) situation individuals behave in different way, the learning effect is not homogeneous for all. Some persons develop rigid strategies, other do not. Other differences emerge in the same way the first part influences the second. The estimations on the tendency to be repetitive in the second part are not homogeneous between the two groups.
The strategy and the performance of the first part, and the following influences on the individual behaviour of each team members determine the functioning of the group.
The compositions of the team, therefore, matters, confirming the relevance of the individual behaviour and suggesting the role of heterogeneity within groups in determining the way in which a task requiring cooperation and coordination is performed.

References

- Bonini N. and Egidi M. (1999) Cognitive Traps in Individual and Organizational Behavior: Some Empirical Evidence, *Revue d'Economie Industrielle*, 88-2, pp. 153-185
- Carpenter M and Gold B.R., (1997), Perceived Managerial discretion: a study of cause and effect, *Strategic Management Journal*, Vol. 18 (3), pp. 187-206
- Coase, R. H. (1937), *The Nature of the Firm*, Economica, 4, pp. 386-405
- Cohen M.D., Burkhart R., Dosi G., Egidi M., Marengo L., Warglien M., Winter S. (1996), Routine and Other Recurring Action Patterns of Organizations: Contemporary Research Issues, in *Industrial and Corporate Change*, 5 (3), pp. 653-98
- Davis-Blake, A., and Pfeffer, J. (1989). Just a mirage: the search for dispositional effects in organizational research, *Academy of Management Review*, 14 (3), pp. 385-400.
- Egidi M. (2002), "Biases in Organizational Behavior", in Augier M. and March J.J. (eds), *The Economics of Choice, Change and Organization: Essays in Memory of Richard M. Cyert*, Aldershot: Edward Elgar
- Egidi M. and Narduzzo A. (1997), The emergence of path-dependent behaviours in cooperative contexts, *International Journal of Industrial Organization*, 5, pp. 677-709
- Egidi M. and Rizzello S. (2003), *Cognitive Economics,* Two volumes for the series The International Library of Critical Writings in Economics, Aldershot: Edward Elgar
- Foss N.J. (1994), The Theory of the Firm: The Austrians as Precursors and Critics of Contemporary Theory, *The Review of Austrian Economics*, 7,1, pp. 31-65.
- Hayek F.A. (1945), The Use of Knowledge in Society, *The American Economic Review*, Vol. 35, 4, pp. 519-530
- Knudsen T. and Foss N.J. (1999), *Dispersed Knowledge and Firm Organization: Fragments of an Austro-Evolutionary Approach - Paper Prepared for the workshop on "Austrian Economics and the Theory of the Firm"*, Copenhagen Business School, 16-17 August
- Langlois R.N. (1994), *Do Firms Plan?,* Papers prepared for the conference "Frontières de la firme", Université Lumière/Lyon 2, January 28, 1994, Lyon, France
- Levinthal D.A. e March J.C. (1993), The Miopia of Learning, *Strategic Management Journal*, 14, pp. 95-112
- Novarese M. (2002), *Lealtà, apprendimento e innovazione, tra teoria dell'impresa e organizzazione aziendale: una lettura cognitiva*, Working papers, Dipartimento di Scienze Giuridiche ed Economiche, Università del Piemonte Orientale
- Novarese M. (2003a), "Toward a Cognitive Experimental Economics", in Rizzello S. (ed) *Cognitive Paradigms in Economics*, Routledge, London (downloadable as a working paper at http://d.repec.org/n?u=RePEc:wpa:wuwpex:0211002)
- Novarese M. (2004a), *Simulations, theory and experiments. Notes from an historical perspective*, forthcoming in the Proceedings of the Wild@ace Conference 2003, World Scientific Publishing (downloadable at the url www.novarese.org/sim.htm)

- Novarese M. (2004b), *Learning in different social contests*, paper prepared for the Sabe/Iarep Conference: Cross-Fertilization Between Economics and Psychology, Philadelphia (downloadable at http://d.repec.org/n?u=RePEc:wpa:wuwpga:0405008&r=cbe)
- Novarese M. and Rizzello S. (1999) Origin and Recent Developments of Experimental Economics, *Storia del Pensiero economico*, 37 (also available on line at the url: http://www.cce.unifi.it/dse/spe/indici/numero37/nova.htm)
- Novarese, M. and Rizzello, S. (2002), *A cognitive approach to individual learning: theoretical issues and some experimental results*, Working papers, Dipartimento di Scienze Giuridiche ed Economiche, Università del Piemonte Orientale (downloadable at http://d.repec.org/n?u=RePEc:wpa:wuwpgt:0301001)
- Novarese and Rizzello (2004), "Satisfaction and Learning: an experimental game to measure happiness" in *The Law and Economics of Irrational Behavior*, F. Parisi and V. Smith (eds), Princeton University Press (downloadable as a working paper at http://d.repec.org/n?u=RePEc:wpa:wuwpmi:0306004&r=cbe)
- Novarese M. and Rizzello, S. (2004b), "The intermingling between cognitive economics and experimental economics", 2004, paper prepared for the "LIII ème Congrès annuel de l'Association Française de Science Economique", September 2004 (downloadable at http://d.repec.org/n?u=RePEc:wpa:wuwpmh:0406004&r=cbe)
- Olffen W. van, and Boone C. (1998), *Psychological team composition and strategy making: team level locus of control in relation to planning quality and action consistency*, NIBOR Research Memorandum, Maastricht: NIBOR.
- Olffen, W. van, and Boone C. (2003), *Team Composition, Leadership And Information-Processing Behavior. A Simulation Game Study Of The Locus-Of-Control Personality Trait*, No 35 in Research Memoranda from Maastricht: METEOR, Maastricht Research School of Economics of Technology and Organization
- Penrose E.T. (1959), *The Theory of the growth of the firm*, Oxford: Oxford University Press
- Rizzello S. (1999), *The Economics of the Mind*, Aldershot: Edward Elgar
- Schumpeter J. (1943), *Capitalism, Socialism, Democracy*, London: Allen & Unwin
- Siegel S. e Fouraker L.E. (1960), *Bargaining and Group Decision Making: Experiments in Bilateral Monopoly*, Mc Graw-Hill, New York
- Simon H.A. (1991), Organizations and Markets, *Journal of Economics Perspective,* Volume 5, Number 2 (Spring), pp. 25-44
- Simon H.A. (1993), Altruism and Economics, in *The American Economics Rewievs*, Vol. 83, 2 May, pp. 156-161
- Simon H.A. (1992), "Colloquium with H. A. Simon", in Egidi M., Marris R., (eds.), *Economics, Bounded Rationality and the Cognitive Revolution*. Elgar, Aldershot
- Weiss, H.M., & Adler, S. (1984), "Personality and organizational behaviour". In B.M. Staw, & L.L. Cummings (Eds.), *Research in Organizational Behavior* (pp. 1-60). Greenwich, JAI Press
- Witt U. (1998), Imagination and leadership - The neglected dimension of an evolutionary theory of the firm, in *Journal of Economic Behavior & Organization*, 35, pp. 161-177